SUMMER 1980
ÉTÉ 1980

# CANADA AGRICULTURE

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# CANADA AGRICULTURE

**VOLUME 25 SUMMER 1980 No. 3**
**VOLUME 25 ÉTÉ 1980 N° 3**

RÉDUCING SALMONELLAE IN POULTRY ... 3
RÉDUCTION DE L'INCIDENCE DES SALMONELLES CHEZ LA VOLAILLE ... 5
SOIL NITROGEN ... 9
THE CONTRIBUTION OF LEAVES TO RAPESEED YIELD ... 11
SOIL PHOSPHATE AS A CANADIAN AGRICULTURAL RESOURCE ... 13
QUANTITATIVE APPROACH IN SOIL MAPPING ... 18
ONION PRODUCTION IN THE MARITIMES ... 19
LE RENDEMENT DU DACTYLE PELOTONNE SEME DANS L'ARGYLE DE KAMOURASKA ... 21
TRICHINOSIS — A ZOONOTIC TIME BOMB ... 22
ERGOT CONTAMINATION OF FEEDS AND FOOD ... 25
EVALUATING THE BREEDING SOUNDNESS OF BEEF BULLS ... 29
ECHOES ... 31

**IN THE NEXT ISSUE...**

- Food Fuel and Famine
- Food of Animal Origin
- Range Inventory in British Columbia
- Water Fowl Damage to Cereal Crops
- World Conservation Strategy

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La revue trimestrielle *CANADA AGRICULTURE* renseigne les vulgarisateurs et représentants du négoce agricole sur les développements de la recherche et des autres services agricoles du gouvernement fédéral.

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Agriculture Canada

**COVER**
**Agriculture Canada's Salmonella research includes immunization strategies for baby chicks. Story on page 3.**

**COUVERTURE**
**La recherche sur les salmonelles, effectuées par Agriculture Canada, comprend des programmes d'immunisation des poussins. Voir l'article à la p. 3.**

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# REDUCING SALMONELLAE IN POULTRY

C. RIGBY

Scientists in four of Agriculture Canada's Animal Pathology Division laboratories have developed some promising new approaches to help reduce salmonella contamination of poultry. Canadian consumers are increasingly aware of the potential health hazard represented by the presence of these bacteria in meat products. The poultry industry and Agriculture Canada are actively seeking measures to reduce contamination in poultry. Because most of the fresh poultry produced and consumed in Canada are broiler chickens (about 300 000 000 birds annually) our studies are directed towards reducing salmonellae in broilers.

Studies are being conducted in Animal Pathology's Atlantic Area laboratory at Sackville, New Brunswick by Dr. Bruce Truscott; in Winnipeg, by Dr. Tej Bhatia; in Vancouver by Dr. Bill Dorward; and at the Animal Diseases Research Institute (ADRI) in Nepean, near Ottawa, by Dr. Jim Pettit and myself. In order to identify the important sources of product contamination Dr. Bhatia and Dr Dorward are studying commercial production facilities and processing plants, in cooperation and consultation with the broiler industry. Dr. Truscott is developing a promising new vaccine to increase the resistance of broilers to infection with salmonellae. At the ADRI, we are studying another method of protecting young chicks from salmonella infection, which involves treating them with anaerobic bacteria isolated from adult chickens. We are also studying the sources and spread of salmonella infection in young broiler flocks. We have been

ARDI technicians Debbi McCabe and Lauraine Caya examine Salmonellae identification tests.

fortunate at ADRI in Ottawa in having access to two rather unique facilities. The first is a poultry barn in which experiments can be conducted involving as many as 2000 chickens raised under conditions similar to those encountered by commercial growers. This barn, especially designed for work with pathogens, is completely self-contained, and can be disinfected between experiments. The second is the Central Poultry Test Station (CPTS), operated at the Central Experimental Farm in Ottawa by the Livestock and Poultry Division. CPTS conducts performance tests of commercially-available broiler strains. Joint studies of salmonellae are also being conducted in these flocks.

These studies have yielded some very useful information about how salmonellae are introduced into broiler flocks, how they survive and multiply in the flocks, how they are introduced into the processing plants, and how they ultimately contaminate the poultry products sold to the consumer. Some promising approaches for reducing this contamination are being developed, and some others have been suggested. The objective of these studies is the reduction of salmonellae in poultry through the design and implementation of effective control measures.

The problem, however, is complex. There are over 1800 types of salmonellae and most can infect many species of animals and birds without causing disease. The bacteria survive and multiply in the intestines and are excreted in the feces, contaminating the environment. They may remain viable for prolonged periods in dust, manure, litter or bedding, or animal products used in the manufacture of animal feeds.

Broiler chickens, like other animals, are susceptible to infection with salmonellae. A salmonella-infected flock grows just as well as an uninfected flock. The number of infected flocks in Canada is unknown. The only way to detect infection is by bacteriologic culture of the birds or their litter. Both the Winnipeg and Vancouver laboratories are currently culturing samples collected from commercial flocks in order to determine the proportion of infected flocks.

Once a flock is infected, it appears almost impossible to eradicate the salmonellae. Administering antibiotics may merely prolong the infection. Therefore, attempts to reduce salmonellae are best

directed towards preventing the introduction and spread of infection. For these attempts to be successful, it is first necessary to determine how salmonellae are introduced into flocks. Our evidence indicates that the major sources of infection may be different in different parts of Canada. For example, although feed was shown to introduce salmonellae into flocks raised in Sackville and at the CPTS in Ottawa, salmonellae were not isolated from feed samples in Winnipeg. However, samples of new straw, which is used as litter in that area, were found to be contaminated, and were the source of infection for flocks raised on that litter. In contrast, at the ADRI we have cultured several hundred samples of new wood shavings, which are used as litter in this area, but we have not yet isolated salmonellae from this material.

Broiler chicks are supplied to the producer by commercial hatcheries, which hatch eggs obtained from parent or multiplier flocks. Transmission of salmonellae from infected parent flocks to newly-hatched chicks has been reported. At the ADRI, we have isolated salmonellae from a limited number of samples collected from commercial hatcheries, but we have failed to isolate any from samples collected at the CPTS hatcher, where strict hygienic procedures are practiced, even though the parent flocks were shown to be infected. The Winnipeg laboratory is currently sampling day-old chicks from a number of commercial hatcheries, to see if day-old chicks appear to be a major source of infection for Manitoba flocks.

Recently, results of our joint ADRI-CPTS study have shown that the plastic crates, which are used in this part of the country to ship broilers to processing plants, may be a very important source of salmonellae if they are not adequately disinfected between flocks. Measures to reduce this source of contamination are now being studied. A similar survey was done about the same time by the Vancouver laboratory. The processing plants which they sampled used large wire cages to transport the birds. In contrast to the results obtained in Ottawa with plastic crates, very few wire cages were contaminated. Where this type of cage is used, shipping may not be an important source of salmonellae.

It is clear from these studies that control measures, in order to be most effective, must be designed and implemented according to the characteristics of the broiler industry in each area of the country.

Studies are also directed towards making the chickens themselves more resistant to infection. At Sackville, Dr. Truscott has developed a vaccine to immunize chicks against salmonellae. This vaccine is an antigenic preparation, derived from salmonella cells, which is mixed with the feed and administered throughout the life of the flock. The protective effect of the oral vaccine is tested experimentally using two groups of chickens; one group is fed the vaccine, and the other (untreated control group) is fed regular feed. When the chickens are about three weeks old, both groups are given live, infectious salmonellae. Samples collected from each chicken during the next weeks are cultured to determine the number of infected carriers. In several trials, the vaccine conferred significant protection to the treated chicks. Improved methods of preparing vaccines containing the most common types of salmonellae are now being developed.

Another promising method for reducing salmonellae is being studied. This approach is based on the phenomenon of competitive exclusion and stems from the observation that older chickens are much more resistant than chicks to infection with salmonellae. It has been suggested that the anaerobic bacteria which populate the intestines of adult birds exclude salmonellae. In 1973, Dr. E. Nurmi in Finland reported that providing young chicks with these bacteria increased their resistance. This effect has been demonstrated in small flocks. For each experiment two groups of day-old chicks are used — a treated group which is given a culture of adult intestinal bacteria, and an untreated control group. Both groups are exposed at three days of age to live, infectious salmonellae. Infection is monitored by regular culture of the litter and birds until the flocks reach market age at about seven weeks. Under these conditions the treatment reduced infection compared with the control group. Trials in larger flocks are now in progress, in cooperation with CPTS. We hope to demonstrate the efficacy, safety, and reproducibility of this method, so that field trials can be planned. We also plan to conduct further experiments at ADRI in which young chicks will be treated with the bacterial cultures and also fed the oral vaccine developed by Dr. Truscott, to see if protection is further increased by a combination of both treatments.

These studies depend on cultural procedures to determine the presence and incidence of salmonellae. Improvements are needed

in procedures, to increase their reliability and sensitivity, and to decrease the cost and time necessary to obtain a result. At the ADRI we have developed an extra enrichment method, which has increased considerably the sensitivity of our cultural procedures. More information is being gathered on the economy and acceptability of this new method. A fluorescent antiserum, capable of detecting most of the common types of salmonellae by the fluorescent antibody (FA) test was developed by Dr. Alex Robertson at ADRI before his retirement. The test is being evaluated in comparison with standard culture methods by the Winnipeg laboratory. It is hoped that the use of this method will permit the rapid detection of salmonellae in larger numbers of environmental samples than standard methods.

All eight of Animal Pathology Division's laboratories participate in national poultry products surveys which are organized in cooperation with Health and Welfare Canada. Each laboratory cultures poultry samples collected in that region. Thus, once preventive measures have been developed and implemented in the various regions of Canada, ready means are available to determine if they are indeed effective in reducing salmonellae in poultry. The technology now being developed will be useful in future efforts to reduce salmonellae in other food-producing animals.

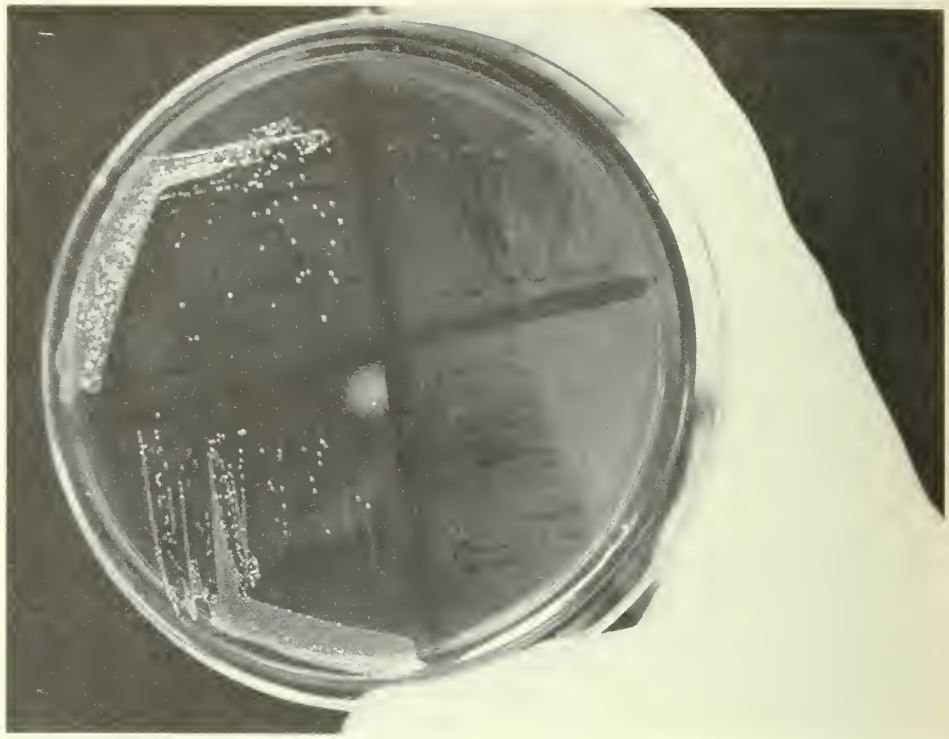
Dr Rigby is a Bacteriologist with Agriculture Canada's Animal Diseases Research Institute, Ottawa

# RÉDUCTION DE L'INCIDENCE DES SALMONELLES CHEZ LA VOLAILLE

C. RIGBY

Les chercheurs de quatre laboratoires de la Division de la pathologie vétérinaire d'Agriculture Canada ont mis au point de nouvelles techniques qui devraient contribuer à réduire la contamination de la volaille par les salmonelles. Les consommateurs canadiens sont de plus en plus conscients des risques pour la santé que représentent ces bactéries dans les produits carnés. Par ailleurs, le secteur avicole et Agriculture Canada déploient actuellement beaucoup d'efforts pour implanter des mesures qui régleraient ce problème. Présentement, nos études se concentrent sur les poulets à griller puisque ce type de volaille forme la majeure partie des produits avicoles consommés au Canada (300 000 000 poulets par année).

On immunise les poussins d un jour contre les bacteries en diluant une solution anti-bacterienne dans leur eau potable



Une culture bactériologique avec des échantillons de salmonelles prélevés sur des poulets

Les travaux actuellement poursuivis dans ce domaine se trouvent sous la direction de M. Bruce Truscott au laboratoire de Sackville (Nouveau-Brunswick) dans la région de l'Atlantique, de M. Tej Bhatia à Winnipeg, de M. Bill Dorward à Vancouver et finalement de M. Jim Pettit et de l'auteur de ces lignes à l'Institut de recherches vétérinaires à Nepean, près d'Ottawa. Afin d'identifier les principales sources de contamination, MM. Bathia et Dorward étudient présentement les installations de production commerciale et de transformation en collaboration avec le secteur du poulet à griller de leurs régions respectives. M. Truscott est en voie de mettre au point un nouveau vaccin qui devrait accroître la résistance des poulets à griller aux salmonelles. Pour leur part, les chercheurs de l'Institut de recherches vétérinaires étudient une autre méthode de protection qui consiste à donner aux poussins des bactéries anaérobies isolées de l'intestin des poulets adultes. Les sources de salmonellose et la propagation de la maladie dans les troupeaux de jeunes sujets à griller sont également à l'étude. Les chercheurs de l'Institut ont la chance d'avoir accès à deux installations d'un caractère plutôt unique: tout d'abord un poulailler dans lequel peuvent se poursuivre des expériences sur un troupeau de 2000 poulets élevés dans des conditions analogues à celles qu'on rencontre dans les élevages commerciaux (ce poulailler, spécialement conçu pour l'étude des agents pathogènes, est complètement isolé et peut être désinfecté après chaque expérience), et ensuite la station centrale d'essais avicoles, exploitée par la Division de la réglementation des produits animaux à la ferme expérimentale centrale d'Ottawa. La station sert aux épreuves de rendement sur les lignées commerciales de poulets à griller et a déjà utilisée dans le cadre de divers projets conjoints sur les salmonelles.

Jusqu'à maintenant, les résultats expérimentaux ont fourni des renseignements très utiles sur la façon dont les salmonelles s'introduisent dans les troupeaux de poulets à griller, y survivent et y prolifèrent, pénètrent dans les usines de transformation et finissent pas contaminer les produits destinés aux consommateurs. On est actuellement à mettre la dernière main à des méthodes prometteuses qui devraient réduire la contamination alors que d'autres solutions ont déjà été avancées. Toutes les études entreprises ont pour objectif principal la diminution de l'incidence des salmonelles chez la volaille, par le développement et l'application de moyens de luttre efficaces.

Le problème est toutefois fort complexe. Plus de 1800 types de salmonelles peuvent contaminer un grand nombre d'espèces animales sans provoquer nécessairement la maladie que l'on connaît. Les bactéries survivent et se multiplient dans l'intestin et se propagent par l'entremise des fèces. Elles peuvent rester en vie durant des périodes prolongées dans la

poussière, le fumier, la litière ou les produits animaux utilisés dans la fabrication des aliments du bétail.

A l'instar des autres animaux, les poulets à griller sont susceptibles d'être contaminés par les salmonelles. Un troupeau infecté se développe aussi bien qu'un troupeau sain. On ignore d'ailleurs le nombre de troupeaux contaminés au Canada. Le seul moyen de déceler l'infection consiste à préparer une culture bactériologique avec des échantillons prélevés sur les oiseaux ou la litière. Les laboratoires de Winnipeg et de Vancouver tentent actuellement, à l'aide de telles cultures, de déterminer la proportion des troupeaux commerciaux contaminés dans cette région.

Une fois le troupeau infecté, il est presque impossible d'éliminer les bactéries. L'administration d'antibiotiques n'a pour effet que de prolonger l'infection. Il est donc préférable de concentrer ses efforts sur la prévention et sur la façon de circonscrire l'épidémie. Pour cela, il faut d'abord déterminer comment les salmonelles se sont introduites dans le troupeau. Il semble que les principales sources de contamination varient d'une région à l'autre du Canada. Ainsi, si les expériences menées à Sackville et à la Station centrale d'essais avicoles d'Ottawa ont révélé que les aliments du bétail se trouvaient à l'origine de l'infection, les échantillons d'aliments mis en culture à Winnipeg étaient parfaitement sains. Dans cette région, l'origine de l'infection a été attribuée à la paille fraîche servant de litière alors qu'à l'Institut de recherches vétérinaires, plusieurs centaines d'échantillons de copeau de bois frais servant aussi de litière et mis en culture, n'ont révélé la présence d'aucune salmonelle.

L'éleveur reçoit ses poussins à griller de couvoirs commerciaux eux-mêmes approvisionnés d'oeufs provenant des troupeaux de souche parentale aussi appelés troupeaux de reproduction. Par ailleurs, on a déjà vu des cas de transmission des salmonelles des troupeaux de souche parentale contaminés aux poussins fraîchement éclos. Des salmonelles ont effectivement été isolées d'un nombre limité d'échantillons prélevés dans des couvoirs commerciaux, mais les échantillons provenant du couvoir de la Station centrale d'essais avicoles, où l'on applique des mesures d'hygiène très strictes, en étaient dépourvus même lorsque les troupeaux de reproduction étaient infectés. Le laboratoire de Winnipeg poursuit présentement un programme d'échantillonnage dans un certain nombre de couvoirs commerciaux pour vérifier si les poussins d'un jour jouent un rôle important dans la contamination des troupeaux du Manitoba.

Les résultats de l'étude menée par l'Institut et la Station centrale ont révélé dernièrement que les cageots de plastique utilisés dans cette région du pays pour livrer les poulets aux établissements de transformation, peuvent être une très importante source d'infection s'ils ne sont pas bien désinfectés entre deux livraisons. On envisage d'ailleurs prendre des mesures visant à régler ce problème. A peu près pendant la même période de temps, le laboratoire de Vancouver effectuait une étude analogue sur les grandes cages de treillis métalliques utilisées par les établissements de transformation pour transporter les volailles. Contrairement aux résultats obtenus à Ottawa avec les cageots de plastique, très peu de ces cages métalliques étaient contaminées. Le transport ne semble plus être une source d'infection importante lorsqu'on a recours à ces cages.

Ces études montrent de façon manifeste que, pour être efficaces, les mesures de luttes doivent être conçues et appliquées en fonction des particularités du secteur du poulet à griller dans chaque région du pays.

Les recherches se concentrent également sur les moyens d'accroître la résistance des poulets aux salmonelles. A Sackville, M. Truscott a créé un vaccin qui immunise les poussins. Il s'agit d'antigènes salmonelliques mélangés aux aliments et donnés aux sujets durant toute leur vie productive. L'effet protecteur de ce vaccin administré par voix orale peut être vérifié expérimentalement à l'aide de deux groupes de poulets; le premier reçoit le vaccin et l'autre (groupe témoin), des aliments ordinaires. A environ trois semaines, les deux groupes de poulets reçoivent des salmonelles vivantes et infectieuses. Les échantillons prélevés sur chaque oiseau au cours des semaines suivantes sont ensuite mis en culture pour déterminer le nombre de porteurs contaminés dans chaque groupe. Plusieurs expériences de ce genre ont révélé que le vaccin protège les poussins de façon efficace. Les chercheurs tentent actuellement d'améliorer les méthodes de production des vaccins contre les sérotypes les plus courants de salmonelles.

Les chercheurs de l'Institut de recherches vétérinaires se penchent aussi sur une autre méthode

prometteuse basée sur le principe de l'antagonisme naturel des bactéries. Cet approche découle du fait que les poulets les plus âgés résistent beaucoup mieux à l'infection que les poussins. Selon cette théorie, les bactéries anaérobies qui peuplent les intestins des sujets adultes y supplantent les salmonelles. En 1973, M. E. Nurmi de la Finlande affirmait que les poussins à qui on fournissait ces bactéries acquéraient une résistance à la salmonellose. Les études canadiennes ont confirmé cette observation dans des troupeaux de petite taille. Pour en faire l'expérience, il suffit de prendre deux groupes de poussins d'un jour et d'administrer à l'un d'entre eux une culture d'entérobactéries de poulets adultes. On expose ensuite les sujets des deux groupes à des salmonelles vivantes infectieuses à l'âge de trois jours. La progression de l'infection peut être suivie par la mise en culture régulière de litière et de tissu animal jusqu'à ce que les oiseaux atteignent l'âge du marché, soit sept semaines environ. Dans ces conditions, le groupe traité est moins contaminé que le groupe témoin. Des expériences portant sur des troupeaux plus importants sont présentement menées en collaboration avec la station centrale d'essais avicoles. On espère ainsi prouver l'efficacité et l'innocuité de cette méthode, de même que la possibilité de l'appliquer à grande échelle. D'autres expériences poursuivies à l'Institut de recherches vétérinaires concerneront le traitement simultané de jeunes poussins avec la culture bactérienne et le vaccin du docteur Truscott, et serviront à déterminer si l'on peut accroître la résistance des sujets par la combinaison des deux méthodes.

Toutes ces études reposent en bonne partie sur le dépistage des salmonelles et la détermination de leur incidence par culture bactérienne. C'est une façon de procéder qu'on peut encore améliorer afin d'accroître sa fiabilité et sa sensibilité et diminuer le coût ainsi que le délai nécessaire à l'obtention d'un résultat. Pour cela, les chercheurs de l'Institut ont mis au point une méthode d'enrichissement qui a amélioré considérablement la sensibilité des techniques de culture bactérienne. Nous accumulons présentement de plus en plus de renseignements sur la rentabilité et l'acceptabilité de cette méthode. Avant de prendre sa retraite, M. Alex Robertson a mis au point à l'Institut un antisérum qui permet de dépister la plupart des sérotypes communs de salmonelle par immunofluorescence. Le laboratoire de Winnipeg compare actuellement cette méthode aux techniques traditionnelles de mise en culture. Son utilisation nous permettra peut-être de déceler rapidement les salmonelles dans des lots d'échantillons plus importants que la technique habituelle de culture ne permet pas de traiter.

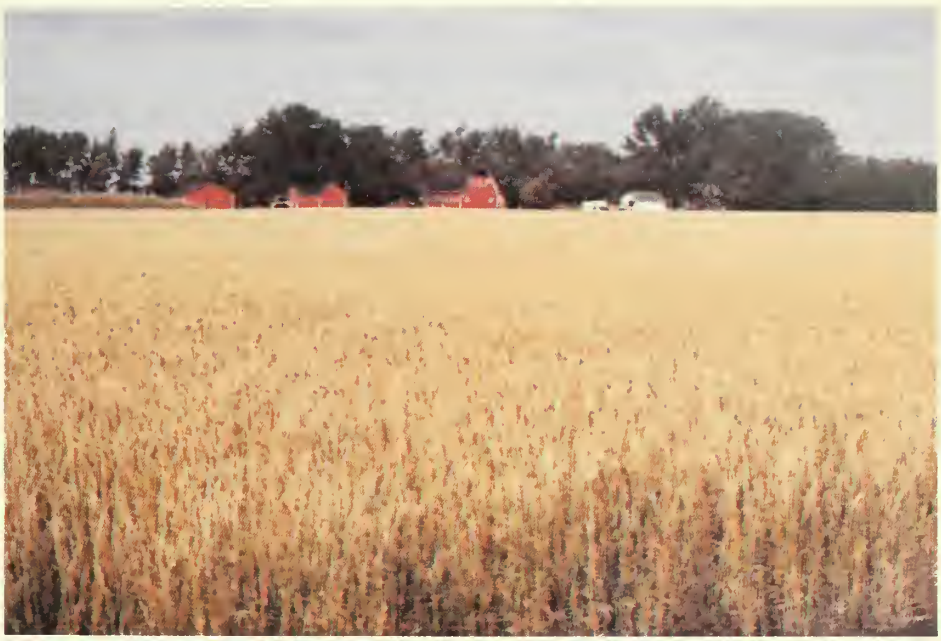
Les huit laboratoires de la Division de la pathologie vétérinaire participent à des études nationales sur les produits avicoles organisées en collaboration avec le ministère de la Santé et du Bien-Etre social du Canada. Chaque laboratoire met en culture des échantillons prélevés dans chaque région. Lorsque des mesures préventives auront été mises sur pied et appliquées dans les diverses régions canadiennes, nous pourrons alors déterminer s'il y a moyen de réduire l'incidence des salmonelles chez la volaille. La nouvelle technologie mise au point nous permettra ensuite de nous attaquer au même problème chez les autres animaux de chair.

Dr Rigby travaille comme bactériologiste à l'Institut de recherches vétérinaires d'Agriculture Canada (Ottawa).

# SOIL NITROGEN

M. SCHNITZER

Les sols contiennent des teneurs considérables d'azote, mais la plupart de ces réserves se retrouvent sous forme combinée à des complexes chimiques qui doivent être transformés en des formes plus simples, comme l'ammoniaque et le nitrate, avant que les racines des plantes et les microbes du sol ne puissent les utiliser. Il faut donc améliorer la synchronisation et l'efficacité de cette conversion avant de pouvoir réduire les applications d'engrais commerciaux basées sur des apports massifs d'énergie fossile. Le recyclage des déchets azotés, la rotation des cultures, le maintien d'une forte teneur en matière organique du sol et une compréhension plus globale du cycle de l'azote permettront d'atteindre cet objectif.



Nitrogen fertilizer can increase wheat yield substantially.

Large increases in crop yields are produced by applying nitrogen fertilizers to soils. Nitrogen fertilizing is based on heavy inputs of nonrenewable energy that continue to increase in price and are harmful to the environment. How can fertilizer applications be reduced? Can more efficient use be made of the relatively large nitrogen reserves in the soil? This article examines soil nitrogen and explores possibilities for developing more efficiency in nitrogen use.

Soil nitrogen is the only essential plant nutrient that is not formed by mineral weathering. Its source is the atmosphere where molecular nitrogen ($N_2$) is the predominant gas, constituting about 79 per cent of atmospheric gases. Only a few microorganisms have the ability to use molecular $N_2$; all remaining living species require combined nitrogen for carrying out their normal activities. The conversion of molecular $N_2$ to combined forms by certain bacteria and algae is referred to as nitrogen fixation. Other sources of soil nitrogen are nitrate and ammonia in rain water. Ammonia in the atmosphere originates from its volatilization from land surfaces, fossil fuel combustion and natural fires.

Nearly all of the nitrogen found in soils is combined with organic matter. Plowed layers may contain between 0.02 and 0.5 per cent nitrogen or 450 to 11 000 kg/ha. As the organic matter decomposes, its nitrogen is converted to ammonia, which is subsequently oxidized to nitrate. In well aerated, cultivated soils nitrate is the predominant plant available form of nitrogen. Grassland soils, by contrast, often contain high levels of exchangeable ammonium but low nitrate levels.

How much do we know about the distribution of nitrogen in Canadian soils? In a recent survey of 82 soils that we sampled from cool temperate zones of southern Canada, extending from the Atlantic to the Pacific, we observed the following: about 40 per cent of the total nitrogen occurred in proteins and peptides, 5 per cent in amino sugars and 28 per cent as ammonia. Assuming that about half of the ammonia was formed during our analysis from complex organic nitrogen compounds, we concluded that about 45 per cent of the total soil nitrogen was unidentified or "unknown". Subsequent experiments showed that up to one-sixth of the unknown nitrogen in Canadian soils consisted of purines and pyrimidines (nucleic acid bases), and practically all of

the unknown nitrogen could be degraded by soil microorganisms with the release of large ammonia concentrations.

Thus, soils contain considerable nitrogen reserves. Even in soils with little organic matter, the top 20 cm contain 2500 to 3500 kg/ha. The proportion of total nitrogen removed by a crop in one year is about 90 kg/ha or 2 to 3 per cent. Why then does the application of commercial fertilizers containing nitrogen increase crop yields so spectacularly? The answer is that most soil nitrogen occurs in chemically complex forms which plant roots and microbes find difficult to utilize, so that soil nitrogen has first to be converted to simpler forms such as ammonia and nitrate. It is because these simpler forms are often not available in the required concentrations at the time most needed that the application of commercial fertilizers, which usually contain ammonia or nitrate or both, has been so successful.

How can soil nitrogen be lost? Nitrate can be rapidly lost from soils by denitrification. The ability to convert nitrate to nitrogen gases ($N_2$, NO and $N_2O$) is limited to a few microorganisms. Favorable conditions for denitrification are poor drainage, temperatures of 25°C and above, near neutral pH and a good supply of readily decomposable organic matter. Nitrogen may be lost by leaching as nitrate, as ammonium by erosion, as ammonia gas from calcareous soils and as nitrogen gases. Recent estimates show that nitrogen losses as gases may account for 10 to 20 per cent of the nitrogen applied in fertilizers.

What about the future? It appears that soils are relatively rich in nitrogen but exist in forms not readily available. Improvement is needed in the timing and efficiency of converting complex nitrogen forms to simpler ones. Since the end of World War II, fertilizer nitrogen has filled the gap, contributing to higher crop yields. But this has required massive input of fossil energy no longer readily available and which will be even less available in the future. In many instances, fertilizer nitrogen has been applied in excess, and some of this nitrogen has been carried off into lakes and streams in run-off waters. A major objective of the 1980s, therefore, is more efficient use of nitrogen already in the soil rather than continuing to rely on heavy applications of commercial nitrogen fertilizers.

There are several ways by which this can be achieved.

It may be advantageous in some soils to reduce large nitrogen reserves by inducing the conversion of unavailable nitrogen to available forms. This has to be done carefully to avoid lowering the soil organic matter content of which soil nitrogen is a part. Present day agricultural techniques tend to suggest lowering soil organic matter when more organic matter is needed.

Techniques must be developed that will reduce losses through volatilization, leaching and denitrification of both native and applied nitrogen from soils.

Recycling nitrogenous wastes from humans, animals and plants could replace some fertilizer nitrogen. Crop rotations also play an important role. Legumes and grasses tend to increase organic soil nitrogen, while corn roots increase the mobility of nitrogenous compounds.

Probably the most important objective is to maintain a high organic matter level in soils and to speed up all reactions that are involved in the nitrogen cycle. This will result in the availability of more ammonia and nitrate to plant roots and microbes and bring about a more dynamic soil system. The eventual development of additional plant species that can fix their own nitrogen will help. What is needed is a more comprehensive understanding of the major chemical and biochemical reactions that control the soil nitrogen cycle. This will hopefully lead to the means for regulating and controlling key reactions such as the conversion of complex organic nitrogen to ammonia. Soil chemists and biochemists in Agriculture Canada's program are currently working to achieve this.

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# THE CONTRIBUTION OF LEAVES TO RAPESEED YIELD

D.J. MAJOR, J.B. BOLE and W.A. CHARNETSKI

Par suite des observations voulant que les feuilles du plant de colza meurent souvent juste après la floraison, alors même que la formation d'hydrates de carbone est indispensable à la production de graines, on a effectué des essais pour déterminer la proportion du tissu foliaire ainsi affectée et savoir si d'autres parties du plant prenaient la relève en matière de photosynthèse. On a constaté qu'en plus des feuilles, les tiges et les siliques étaient capables de photosynthèse.

Bien que les feuilles meurent trop tôt, la capture vitale d'énergie par la tige et les siliques permet aux graines de se développer. Toutefois, les feuilles demeurent la principale source d'hydrates de carbone pour la production de graines, de sorte qu'il est avantageux de prolonger la vie des feuilles. On a découvert quatre cas de nécrose précoce des feuilles, soit les carences d'azote, les stress hydriques, les fortes densités de peuplement et les déséquilibres entre les parties du plant qui captent l'énergie et celles qui l'utilisent. Les feuilles constituent un facteur important du rendement du colza et les pratiques de gestion agricole qui permettent d'en prolonger la vie sont capitales pour obtenir un rendement maximum.

Figure 1 Leaf senescence of drought-stressed rape plants (right) compared with non-stressed plants (left)

Crop plants harvested for seed have four different types of structure: roots, stems, leaves and flowers. The root supplies moisture and mineral nutrients to the whole plant and is important for support. The stem also provides support and conducts water and nutrients to the leaves and flowers. The leaves provide carbohydrates for growth and development by using light energy to convert carbon dioxide and water into sugars necessary for growth (photosynthesis). The flower bears the seed.

In the early 1970s we initiated a series of experiments to study the premature death of rape plant leaves. We had observed that the rape leaves died just after flowering, which meant that the source of carbohydrates for seed growth was disappearing when most needed.

These physiological studies were important to rape production because the results would determine if rape leaves really are important and if changes in management practices would prevent leaf losses. It also provided information for plant breeders on how the rape plant should be modified to increase its yield potential.

Initial experiments were designed to measure how much leaf tissue was dying. We found that when the seeds began to grow rapidly the leaves began to die. Also, the rate of senescence of the leaves was much higher and more severe in the early maturing Polish rape varieties than in the later Argentine.

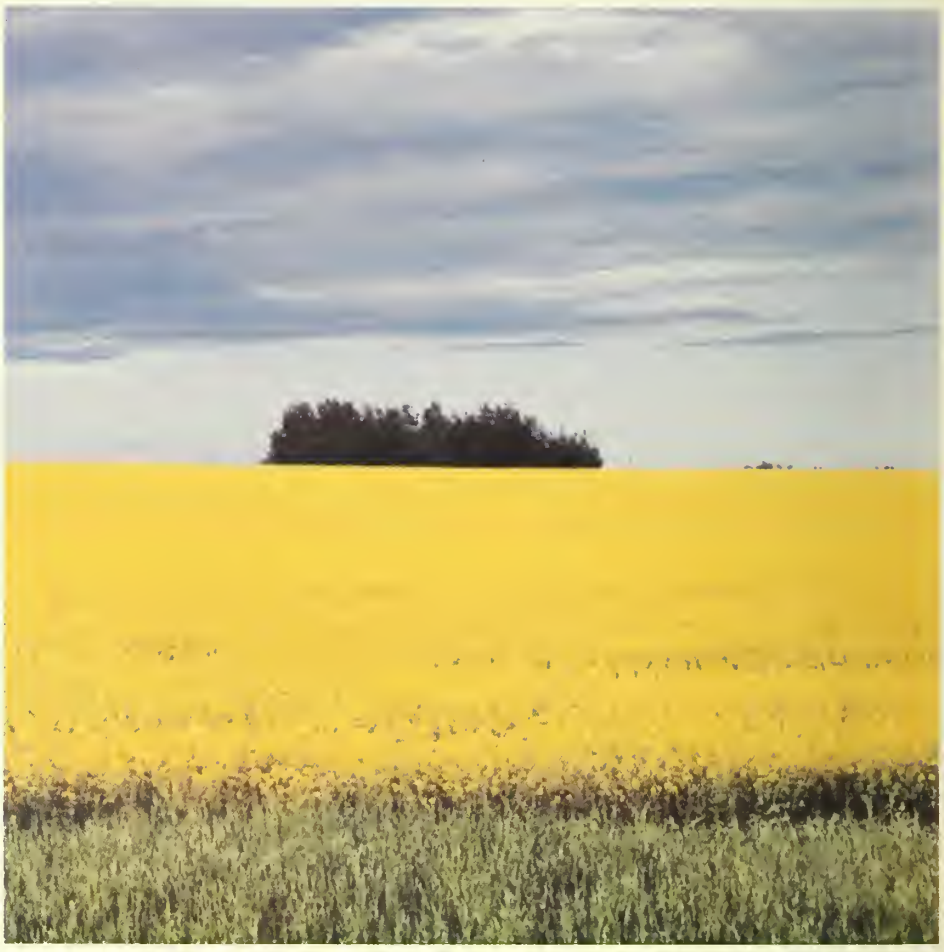
Other questions to be answered were as follows: if leaves died too early, was some other plant part photosynthesizing; and to what extent was yield being reduced by leaf loss? In a series of studies using various crop physiology techniques, such as growth ana-

lysis, radioactive carbon-14 assimilation analysis, and stomatal frequency and distribution determinations, it became apparent that, in addition to the leaves, the stems and pods were also capable of photosynthesis.

The leaves on the lower portion of the stem provided the energy for the roots, and the carbohydrates produced in the upper leaves supplied energy for growth of the pods and the seeds. The lower part of the stem was able to photosynthesize at a rate high enough to meet its own energy needs, and the upper stem provided carbohydrates for itself, the pods and the seeds.

The pod is complicated because it performs two types of photosynthesis. On the outside of the pod, carbon dioxide from the air moves through stomata into the pod tissue and is fixed through photosynthesis. The resulting carbohydrate is transferred to the seeds within that pod or used for growth of the pod itself. The seed is a reservoir for storing energy fixed in the other parts of the plant. This energy comes in as sucrose and is then converted into starch, oils and protein. Energy is required for these conversions and carbon dioxide is released into the pod cavity where it is reassimilated at the inner wall of the pod. Although we were unable to measure it, photosynthesis may be occurring in the seeds themselves.

We concluded that even though leaves died too soon, the vital capture of energy from the sun by stems and pods still allowed seeds to be filled and to reach maturity. Leaves remain the main source of carbohydrates for seed growth. When rape is irrigated leaves remain green longer and seed yields increase.



Rapeseed field

What causes the leaves to senesce? We have studied several factors and have concluded that there are at least four causes: nitrogen deficiencies, moisture deficits, high plant densities and imbalances between parts capturing energy through photosynthesis (the sources) and the parts using the energy (the sinks).

A nitrogen deficiency will cause leaves to die, progressing from the leaves closest to the soil because there is not enough nitrogen being taken up by the roots for the seeds. The nitrogen in the leaves has to be used and as a result of this mobilization, the leaves die. This starts a vicious circle since the lower leaves are also needed to supply energy for the roots to drive the nutrient uptake process.

A moisture deficit will result in leaf death, also starting with the bottom leaves. Since the leaf is a wide thin blade, it has a very efficient shape for intercepting sunlight. Unfortunately, this also makes it waste water. Thus, leaf

loss allows the plant to be a more efficient user of a limited water supply.

High plant densities result in early leaf death, probably because moisture and nitrogen deficits occur as a result of increased plant competition.

The imbalances that exist within the plant may cause leaves to die too soon. The seed (sink) is closer to the leaf (source) than the roots, and is a stronger sink for photosynthate. Eventually, the root is starved and thus fewer minerals are available for the seed. Since rapeseed has a high protein content, roots are important to supply the large amounts of nitrogen needed. Therefore, for the seeds to get sufficient nitrogen for growth, the leaves must be sacrificed. We have indirect proof of this. For example, if the sink (pods and flowers) is removed the source (leaves) stays alive.

The results of this research have shown that leaves are an important determinant of rape yield. Other above-ground tissues, such as stems and pods, are also important photosynthetic organs. The implications are that management practices that will prolong the life of the leaves, such as adequate fertilization and moisture conservation, will increase yield. Since rape is gaining importance as an irrigated crop, breeders should also develop varieties that retain a larger proportion of their leaves at the high population densities used in irrigated rape-production.

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# SOIL PHOSPHATE AS A CANADIAN AGRICULTURAL RESOURCE

DONALD S. GAMBLE

La présence du phosphate comme élément nutritif du sol a une implication à long terme des plus importantes pour l'agriculture canadienne. On préconise une analyse au moyen de modèles informatisés comme approche pour une recherche poussée à ce sujet.

Of three macronutrients, potassium, nitrogen and phosphorus, that are essential to farm crops, phosphorus could be the first to become a supply problem for Canadian agriculture. Canada is a major potash producer. In principle, soil nitrogen can be renewed by bacterial fixation. There is some important research on the agricultural applications of this, in Canada and elsewhere. In contrast to the potassium and nitrogen situations the long-range outlook for phosphorus is much less favorable. There are no Canadian phosphate deposits in commercial production. Almost all of the phosphate rock used for agriculture is imported from Florida. No renewal process comparable to nitrogen fixation is available for soil phosophorus.

For future agricultural use of phosphorus to be economical it must be effective for the growth of crops and must be conserved. In some parts of Ontario, phosphorus has accumulated in cultivated soils during many years of fertilizer applications. As a result, some of the current phosphate applications to these soils are an unnecessary expense. There may be some environmental hazard as well. On the other hand, some Saskatchewan soils are known to be phosphorus-deficient.

Many field experiments have investigated the interactions of crops and phosphate. For example, Figure 1 shows some Saskatchewan work from 1957. The interesting feature here is that fertilizer phosphorus and soil phosphorus are both taken up by the crop, and contribute to the yield of grain. With large tonnages of grains being exported from the prairies every year, the implications must be carefully considered. Unless

fertilizer phosphorus is added, successive crops can deplete the soil phosphate reserve. Some greenhouse experiments (Figure 2) suggest what might happen.

Although fertilizer shortages and phosphate deficiencies in soils may develop in the future, the developed Western countries have avoided such problems because of a sharp increase in the use of phosphate available from Florida. Canada is a typical example, with a 2 1/2 fold increase between 1963 and 1975.

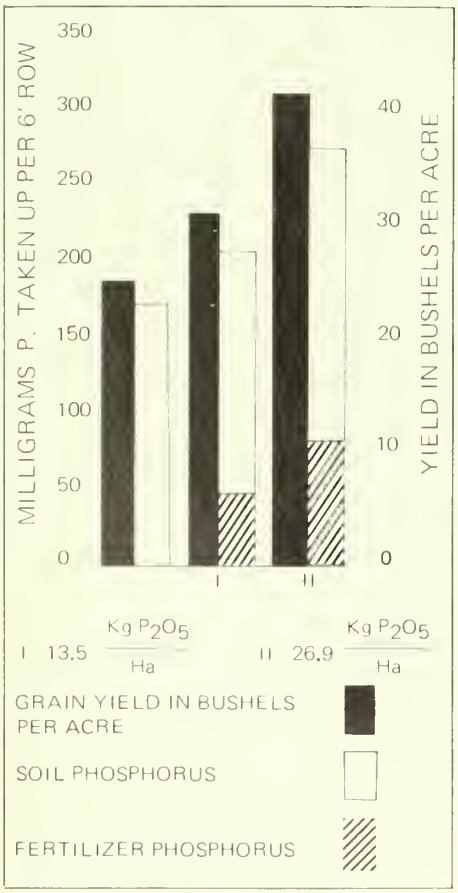


Figure 1. Phosphorus uptake and grain yield, for wheat grown in Saskatchewan. The effects of phosphate from the soil and from ammonium phosphate fertilizer (1).

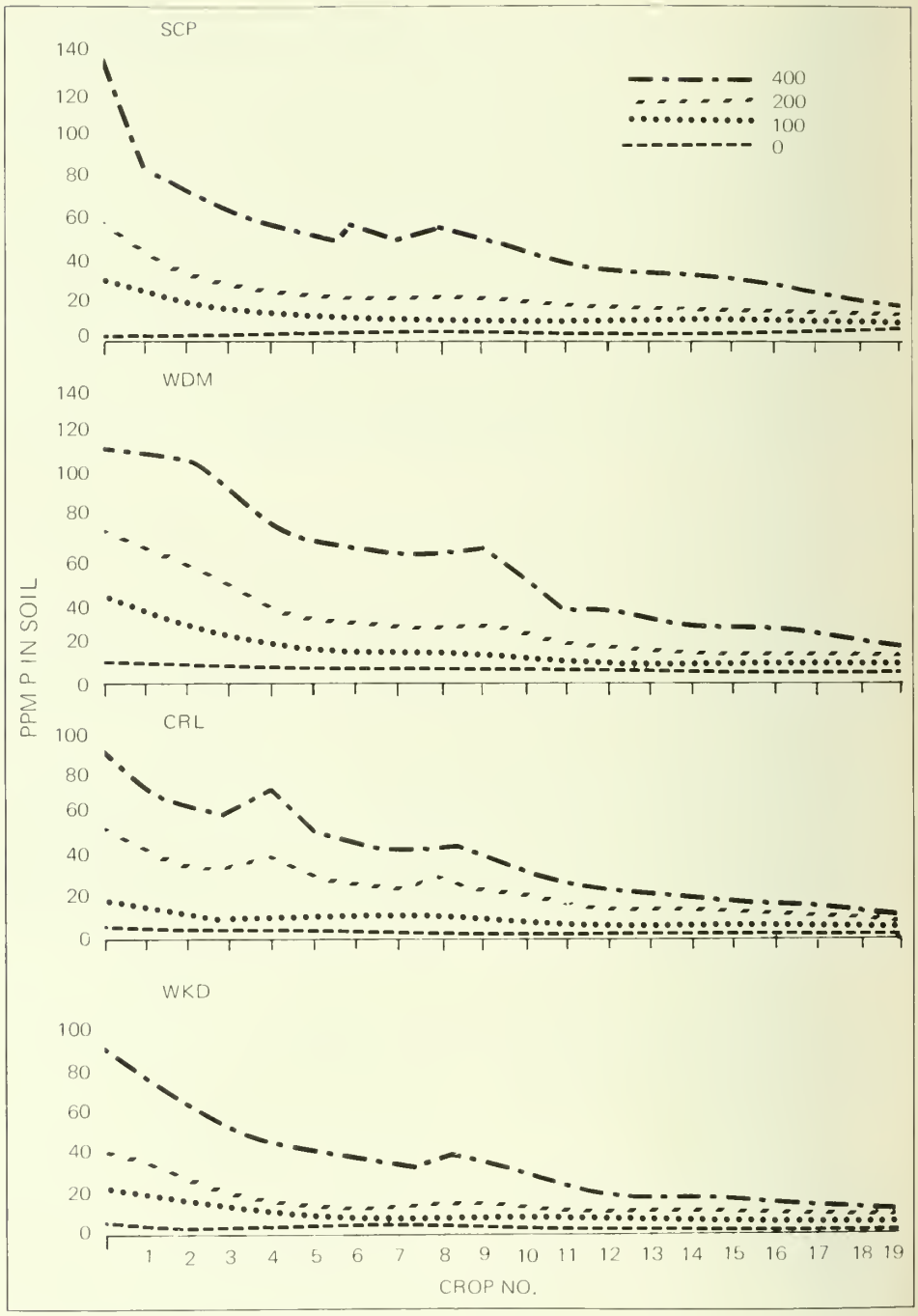


Figure 2. The removal of phosphorus from soils by the successive cropping of grains. Alternate crops of barley and oats in the greenhouse. (2). Examples are shown with four different soils.

This Canadian consumption of fertilizer phosphate is shown (Figure 3). It is instructive to compare annual consumption with the estimated reserves of soil phosphate. If one considers that the top 15 cm of a soil are the most important to agriculture, then one can estimate that the 68 million hectares of total Canadian farmland have an average phosphorus reserve of 898 kg/ha. Evidently this farmland contains a soil phosphate reserve that is about 280 times as great as Canada's 1975 consumption of fertilizer phosphate.

Although one cannot actually predict how long this reserve of soil phosphate will last, it is potentially an economically important agricultural resource. There are at least three reasons for this.

The first is that the world patterns of phosphate production and trade have been changing. While price and consumption increases continue, some American forecasts anticipate a decline in Florida production by about the mid 1980's. This implies that the world's largest high grade phosphate rock deposit, which is in Morocco, will eventually dominate the world market. Anticipating this, the Soviet Union has already negotiated a long term contract for the purchase of Moroccan phosphate rock. The export curves in Figure 4 reflect these developing trends.

The next reason for the importance of the soil phosphate resource is closely related. This is that the production and trade pattern changes could leave Canada vulnerable to yet another foreign cartel. Finally, there is a significant energy cost in the production and application of fertilizer phosphate.

Obviously the most efficient use must be made of agricultural phos-

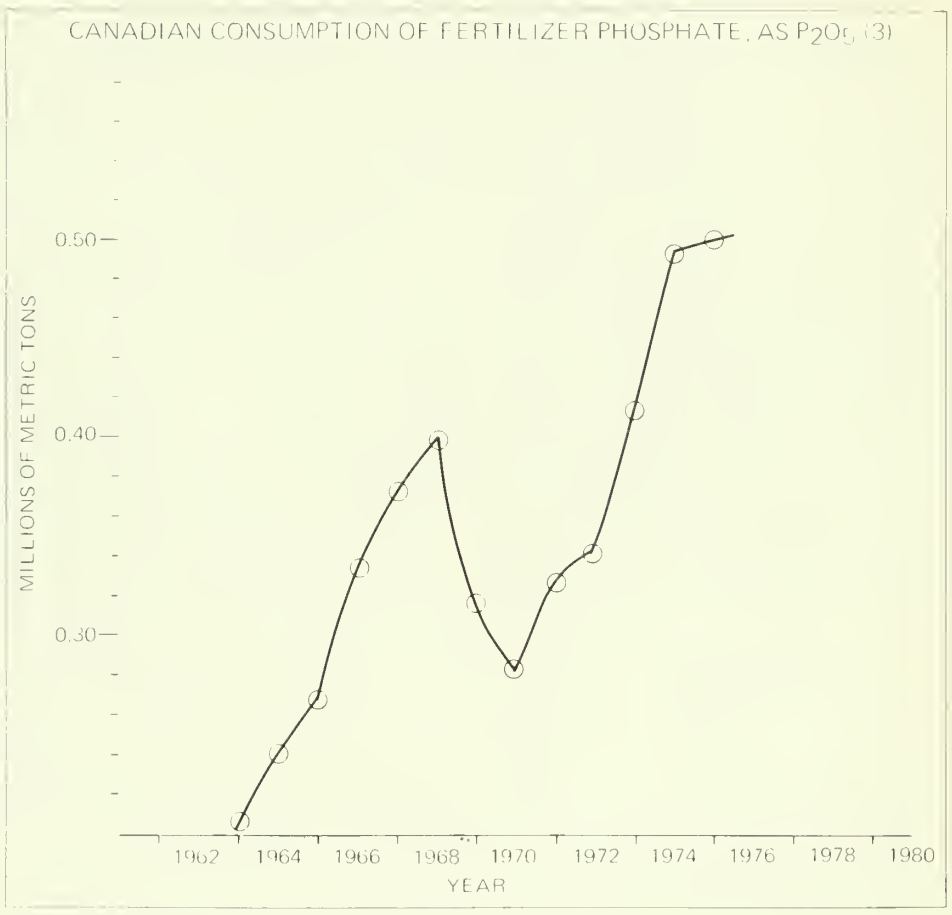


Figure 3. Canadian consumption of fertilizer phosphate, as $P_2O_5$ (3).

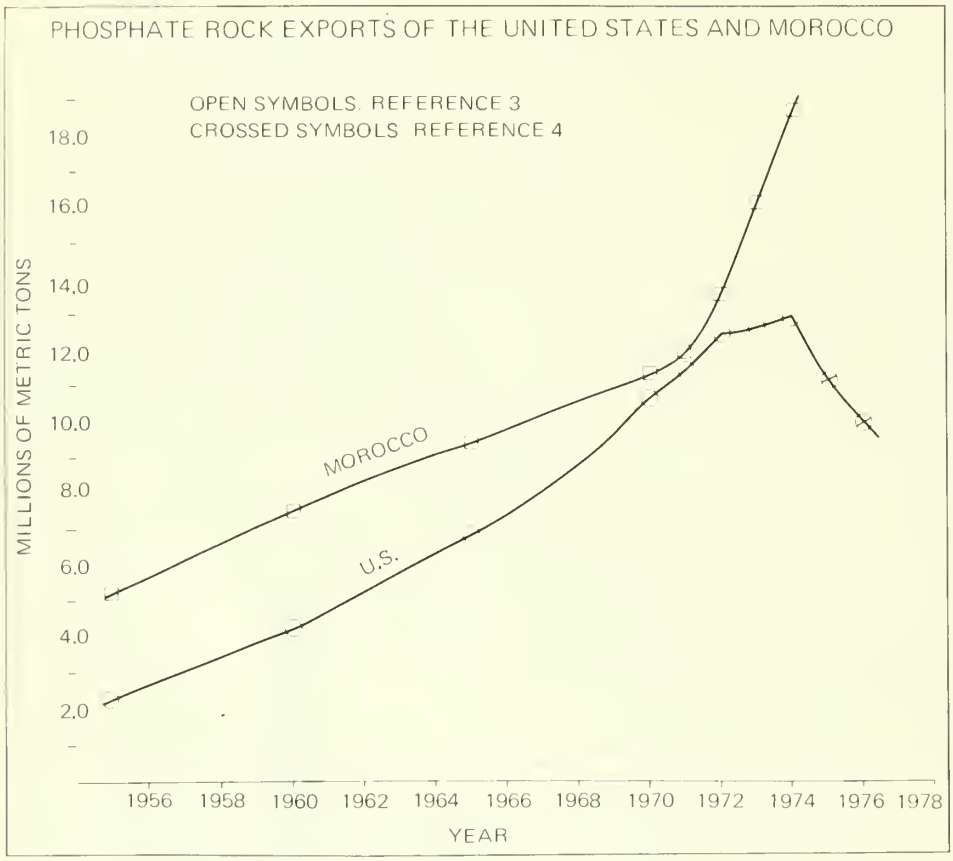


Figure 4. Phosphate rock exports of the United States and Morocco, 1955 to 1976 (3,4).

phate, both to conserve the important soil phosphate resource, and to control farmers' fertilizer costs. This requires a strong program of scientific research.

This need for phosphate research has long been accepted, and a dozen or more agriculturally oriented laboratories across Canada are engaged in some sort of phosphate research. About four colleges and faculties of agriculture participate, as well as two provincial departments of agriculture. In Agriculture Canada, seven Research Branch establishments are doing some phosphate related work.

The soil phosphate system represents a typical multi-disciplinary research problem. It covers the fields of soil science and agronomy. Support is required from such scientific disciplines as microbiology, pedology, and chemistry. Because the problem is quite complex, computerized models must be developed for the application of research results to practical agriculture.

In the development of computer models for soil phosphate systems in Canada, at least two types of cases must be considered. One type includes the alkaline, semi-arid prairie soils. Higher-rainfall, acidic soils characterize the second type.

Soil phosphate research on the Prairie type of systems has been in progress for a number of years at the Saskatchewan Institute of Pedology. This work employs computer modelling, and is being carried out in collaboration with American agricultural scientists. Figure 5 shows a typical soil phosphate model. For the second type of soil phosphate system this kind of integrated research project does not

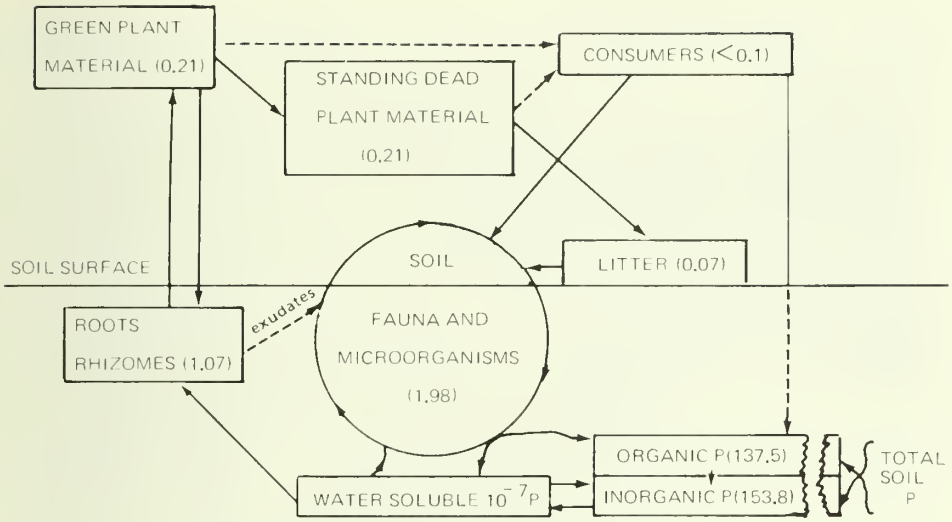


Figure 5. A model for the phosphate cycle of a native grassland (5, 6).

yet exist in Canada. Instead, a considerable portion of the phosphate research in Canada is scattered in fractions of man years. Some of it is only complementary to work having some other focus. A second integrated research project is now required, for the higher-rainfall, acidic soils.

Because of the strategic position of phosphorus in the economics of Canadian agriculture, a stronger research effort is justified for the soil phosphate resource. A systems analysis approach with computerized models should be used for the research.

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# QUANTITATIVE APPROACH IN SOIL MAPPING

C. WANG

La carte pédologique forme la base d'un bon rapport de prospection pédologique. Les unités cartographiques du sol sont les éléments de construction d'une carte pédologique. Pour bien interpréter quantitativement ces cartes en prévision de certaines utilisations du sol, il est essentiel de disposer d'une unité cartographique bien déterminée. Non seulement cette unité détermine-t-elle quantitativement le sol dominant et sous-dominant, mais elle définit également la variabilité du sol au sein d'une même unité et entre les unités différentes.

On utilise actuellement une nouvelle méthode du transect en cartographie pédologique, laquelle permettra d'obtenir des cartes pédologiques statistiquement valables et d'améliorer la qualité des cartes, ainsi que leur interprétation. L'auteur décrit l'utilisation de cette nouvelle méthode en cartographe pédologique.

Conducting a soil survey

Since the first soil survey program was introduced in Canada in 1913, continuous effort has been made to develop a better classification system for Canadian soils. A good soil classification system reflects the current stage of knowledge and concepts and it must be modified as knowledge grows and new concepts develop (Canada Soil Survey Committee, 1978)[1]. In recent years, more quantitative measurements of soil properties have been defined for use as criteria in classifying soils. This is a result of the progress of soil science over the years as well as the increasing public demand for more quantitative interpretion of data in the soil survey reports.

A good soil survey report starts with a reliable soil map. Soil map units are the building blocks of a soil map. In order to interpret soil map units properly and quantitatively for a certain land use, a well-defined map unit is essential. A well-defined map unit must define the dominant soils and subdominant soils quantitatively as well as clearly define the soil variability within and between the different map units.

In most of the current soil survey reports, the land use interpretation has been based primarily on the relatively narrow range (a fraction of the true range existing in a map unit) of the characteristic variation of the dominant soil or soils of a map unit. The authors of soil survey reports usually caution users about the likehood of the existence of contrasting soils or extreme values of a certain soil property, and that the risk of using the ratings in an interpretation table (or map), will vary according to the nature of the map unit. Nevertheless, the extent of the risk or the reliability of the interpretation of a map unit for certain usage is rarely stated in a quantitative way. Because of this, planners and other users tend to be over cautious in some cases, and not careful enough in others. Therefore the problems associated with soil interpretation are not necessarily due to the lack of data for a certain soil map unit, but rather to the fact that the method used to collect the data is often not statistically sound, and consequently, the proper data are not used to characterize scil map units.

Scientists in the Land Resource Research Institute are currently

[1]The Canadian system of soil classification Can. Dept. Agric. Publ. 1646. Supply and Services Canada, Ottawa, Ont. 164 pp

developing a Mapping System for Canada in which a new look, the transect method, will be introduced. Basically, the transect method involves randomly selecting a number of transects along which, at fixed distances observations and/or samples of the soil will be taken for analysis. This new method will not only make soil mapping and soil sampling statistically sound, but also will speed up soil mapping as well as improve the quality of the maps and their interpretation. The soil transect method has application in three different aspects of soil survey work.

**A. In legend establishment and field mapping** — Soil transects can be used to estimate the extent, kind, and nature of potential map units during legend construction by the party leader. The preliminary map unit can then be subdivided or combined as accumulated information dictates during the process of mapping. Soil transects can also be used to replace conventional mapping methods. Steers and Hajek (1979)[2] demonstrated that the transect method increased mapping productivity up to 500 per cent over the conventional soil mapping method while maintaining the same map quality.

**B. In finalizing the soil map and in soil correlation** — Information collected from the transects during the course of the field survey can be used to estimate the composition of map unit delineations and to quantify map units.

By using Arnold's "Graphical solution of binomial confidence limits in soil survey" (1979)[3], random transects can provide a quick and reliable method of correlating map units.

**C. In soil interpretation** — In soil interpretation, it is not always important to know the composition of a mapping unit (i.e. the soil series involved) but rather the range of a certain soil property or properties which are crucial for certain land uses. Therefore, it is important for this purpose to state the range of soil characteristics of a map unit with a certain level of confidence. Made aware of the risk, the user can thereafter more safely plan his investment in site preparation.

The transect method used to characterize soil map units and in field mapping is described in a paper "Transect mapping and its application" in the proceedings of the Expert Committee on Soil Survey, 1980. A reprint of the paper is available upon request.

[2]Determination of map unit composition by a random selection of transects. Soil Sci. Soc. Am J. 43:156-160

[3]Strategies for field resources inventories. Agronomy Mimo 79-20. Dept. of Agronomy, Cornell University, Ithaca, New York 14853.

Dr. Wang is a research scientist in the soil classification section of the Land Resource Research Institute.

# ONION PRODUCTION IN THE MARITIMES

J.A. CUTCLIFFE

Les expériences poursuivies à la Station de recherche d'Agriculture Canada, à Charlottetown (I.-P.-E.), au cours des cinq dernières années, ont démontré qu'il était possible de faire la culture des oignons sur une base commerciale, à l'Ile-du-Prince-Edouard. On estime que la consommation annuelle d'oignons dans les provinces de l'Atlantique équivaudrait à la culture de 500 acres. Cette demande pourrait être satisfaite sur place et aiderait cette région à devenir plus autarcique dans le domaine alimentaire.

The Maritime provinces could become self sufficient in onions. Experiments conducted at Agriculture Canada, Research Station, Charlottetown, during the past five growing seasons have shown that onions can be grown commercially in Prince Edward Island.

Home gardeners, throughout the Maritimes, have grown onions for many years. Most gardeners start with sets rather than seed and have had no trouble drying a bushel or two in the sun or in a ventilated building. Production from sets is generally considered to be too costly for a commercial acreage.

During the past seven years, about mid-May, several varieties of onions were planted at Charlottetown. Weeds were controlled by cultivation and hand hoeing. Early

maturing varieties were generally ready to harvest by late September. Artificial drying was required to cure the bulbs for long term storage. The variety Rocket produced at the rate of about 30 tons a hectare (550 bushels an acre) and was rated as one of the best for maturity. Nutmeg, Ontario M, Autumn Splendour and Autumn Spice also performed sufficiently well to be recommended for grower trial.

Based on the success of these experimental plantings, a tobacco grower was encouraged, with the aid of a Technology Transfer Program, to seed a five acre planting in 1979. Rocket and Autumn Splendour were seeded on May 12 and lifted in early October. Bulk tobacco curing compartments proved to be excellent for curing the partly mature bulbs and the resulting crop was marketed during the winter months. This marks the first successful attempt to produce onions on a commercial scale in Prince Edward Island and could lead to the establishment of a small onion industry in the "Garden Province".

It has been estimated that during the period when local onions could be marketed, the Atlantic region consumes the equivalent of 500 acres of onions annually. Thus the opportunity exists for greater self sufficiency in this phase of food production. Research has shown the way. Industry development is indicated.

Mr. Cutcliffe is a research scientist at Agriculture Canada research station, Charlottetown.

Commercial onion production has potential for P.E.I

# LE RENDEMENT DU DACTYLE PELOTONNÉ SEMÉ DANS L'ARGILE DE KAMOURASKA

L. BELZILE

Winter survival ability is usually associated with legumes rather than grasses. Some grasses are also subject to winter damage but less attention and less research has been devoted to their winter hardiness. Orchard grass, particularly when cultivated and grown for hay on clay, has been disappointing despite early maturity, less sensitivity to drought, and high hay yield potential.

La rusticité des graminées et des légumineuses devient très importante lors de nos hivers rigoureux

Le problème de la survie en hiver des plantes fourragères n'existe pas seulement chez les légumineuses. Il est bien connu que souvent cette famille de plantes supporte mal les rigueurs de l'hiver. La survie en hiver réfère habituellement aux légumineuses mais rarement aux graminées.

Le mil et le brome sont deux espèces fourragères très rustiques qui subissent peu fréquemment des dommages sérieux au cours de notre hiver. Ce sont les espèces les plus cultivées et c'est pour cette raison que dans notre région on prend pour acquis que seules les légumineuses souffrent des méfaits de certains de nos hivers rigoureux.

Le dactyle pelotonné (*Dactylis glomerata*) est une graminée fourragère reconnue pour sa précocité et sa repousse rapide. Ces caractéristiques en font une excellente plante à pâturage ainsi qu'une bonne plante pour la production du fourrage. La courte période productive de notre saison de végétation demande l'emploi d'espèces à maturité hâtive. Or le dactyle, grâce à sa précocité pourrait bien être la seule graminée pouvant nous donner facilement, bon an mal an, deux et même trois coupes de foin. C'est une espèce très feuillue, avec une bonne teneur en matières azotées et moins sensible à la sécheresse que certaines autres graminées cultivées dans la région.

L'étude du comportement du dactyle cultivé sur l'argile révèle que sa tolérance aux températures très froides est faible (tableau 1). La comparaison avec celle de la luzerne cultivée sur le même type de sol fait ressortir cette faible rusticité. Nos résultats démontrent clairement que les deux espèces sont souvent endommagées au courant de l'hiver mais que la luzerne est plus rustique que le dactyle (tableau 1). L'importante faiblesse de cette graminée fourragère expliquerait en bonne partie son manque de popularité. Une production végétale basée principalement sur cette dernière espèce serait souvent aléatoire, donc peu populaire auprès du pro-

TABLEAU 1
SURVIE* À L'HIVER DU DACTYLE ET DE LA LUZERNE CULTIVÉS SUR L'ARGILE KAMOURASKA À LA POCATIÈRE

| Semis du printemps 1972 | | | | | | Semis du printemps 1974 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dactyle | | | Luzerne | | | Dactyle | | | Luzerne | |
| Cultivar | 1973 | 1974 | Cultivar | 1973 | 1974 | Cultivar | 1975 | 1976 | Cultivar | 1975 | 1976 |
| Frode | **1 | — | Alfa | ***39 | 36 | Frode | 86 | 12 | Alfa | 99 | 36 |
| Pennlate | 6 | — | Narraganset | 66 | 26 | Pennlate | 88 | 7 | Narraganset | 99 | 73 |
| Rideau | 29 | — | Vernal | 63 | 26 | Rideau | 83 | 7 | Vernal | 99 | 73 |

* Le pourcentage de survie a été estimé visuellement
** Moyenne de 4 observations
*** Moyenne de 6 observations

Note. A l'exception de l'hiver 1974-75, tous les autres furent très dommageables aux deux espèces fourragères étudiées.

ducteur. La sensibilité du dactyle aux rigueurs de l'hiver est surtout évidente sur les argiles, où il semble mal adapté à ce type de sol malgré un drainage superficiel et souterrain adéquats.

Ces deux espèces ont un comportement similaire face aux rigueurs de l'hiver, malgré que le dactyle soit inférieur à la luzerne côté rusticité. Beaucoup d'efforts sont déployés en vue d'améliorer cette qualité chez la luzerne. Ces efforts sont justifiés car cette espèce occupe une place beaucoup plus importante que le dactyle dans notre système fourrager. Cependant, les nombreuses qualités du dactyle, dont sa précocité, sa repousse rapide, son feuillage abondant, sa bonne teneur en matières azotées, son excellence pour le pâturage et son bon rendement en fourrage, devraient inciter les chercheurs à améliorer sa rusticité. Il ne fait aucun doute qu'en agissant ainsi, la culture de cette plante fourragère deviendrait beaucoup plus importante.

M. Belzile est un spécialiste des récoltes fourragères à la Ferme expérimentale d'Agriculture Canada à Sainte-Anne de la Pocatière (Qué.)

# TRICHINOSIS — A ZOONOTIC TIME BOMB

H.J. SMITH

La trichinose, maladie parasitaire rencontrée chez beaucoup d'animaux carnivores et omnivores, est particulièrement dangereuse pour l'homme. Le ver adulte vit dans l'intestin de l'hôte et l'hôte définitif sert également d'hôte intermédiaire. Les larves abandonnent l'intestin par le système lymphatique pour aller éventuellement s'enkyster dans les muscles.

Le Laboratoire de pathologie animale de Sackville (Nouveau-Brunswick) effectue des recherches sur cette maladie depuis 1971. La détection de quelques porcs infectés chaque année souligne la possibilité d'un foyer explosif d'infestation advenant le manque de mesures permanentes de vigilance et de prévention.

Trichinosis is a parasitic disease that has been found in many carnivorous and omnivorous animals, including man. The adult worm, *Trichinella spiralis*, is ovoviviparous and lives in the intestinal tract of its host. This parasite differs from most parasitic nematodes because the definitive host also serves as the intermediate host. Instead of the larvae (or in the case of many other worms, the eggs) leaving the definitive host before reinfection takes place, Trichinella larvae leave the intestinal tract of the definitive host via the lymphatic

system to eventually encyst in the musculature (Figure 1). Transmission of infection to new hosts is via the ingestion of infected musculature. This explains why the disease is common in carnivores, predators and carrion feeders. Infection occurs in man via the ingestion of rare or improperly cooked infected meat and meat products.

In animals, trichinosis is rarely associated with clinical disease but in man trichinosis causes a very serious disease which in severe infections may lead to death. The disease may be considered from two aspects: the intestinal form due to the adults and the muscular form due to the larval stages. Until recently, there was no satisfactory specific treatment. However, some of the newer anthelmintics have high efficacy against adult worms in the intestinal tract. Some compounds are also active against the muscle larvae but once they have invaded and encysted in the musculature, considerable myopathy has already occurred.

Man contracted trichinosis most often by eating infected pork or pork products but in recent years serious outbreaks have occurred from the ingestion of infected bear, walrus or other game meat.

Trichinosis exists mainly in two forms in Canada. Sylvatic trichinosis occurs in arctic and subarctic areas in flesh-eating mammals such as polar bears, walruses, foxes and other species. Urban trichinosis occurs in temperate areas with a rat-to-rat and a rat-to-pig cycle.

Since 1971, investigations on both sylvatic and urban trichinosis have been carried out in the Atlantic Provinces at the Animal Pathol-

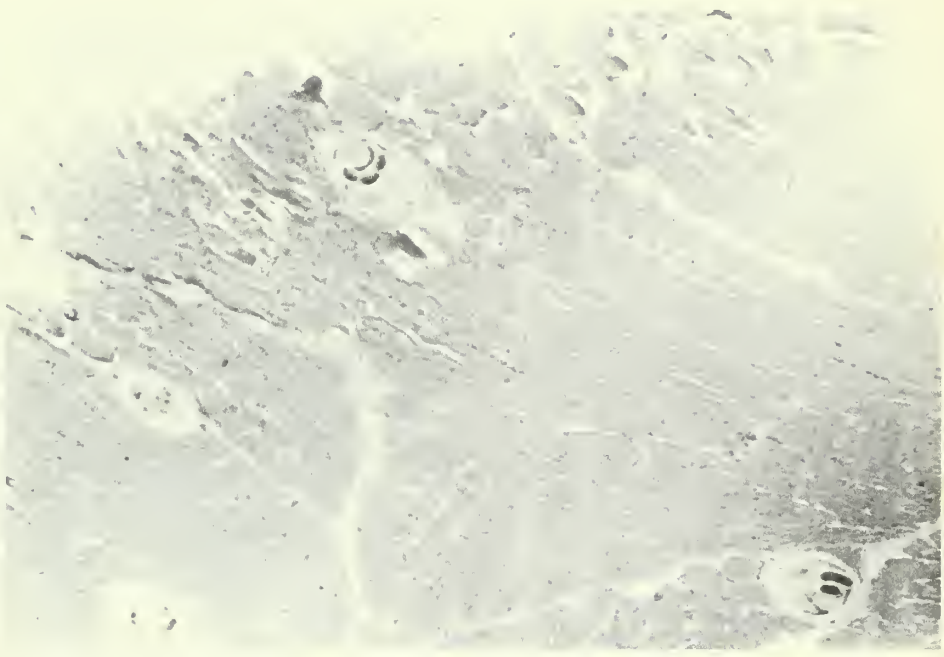


Figure 1 Histologic section of porcine musculature showing encysted Trichinella larvae

Figure 2 Cross section of diaphragm of a field caught rat heavily infected with trichinae

ogy Laboratory in Sackville, N.B. Examination of over a hundred Maritime black bears have failed to reveal any trichinosis although the one polar bear captured in Newfoundland was infected.

During this time four foci of trichinosis in hogs have been uncovered but the incidence of infection remained low. In all foci except Halifax, infected hogs were uncovered on only one premise. The fact that a few infected hogs are uncovered each year points out the potential for an explosive outbreak if constant vigilance and preventative measures are not taken.

A study of the foci uncovered in the Maritimes suggests that rats are important in the transmission and maintenance of infection. In 1971, trichinosis was made a reportable disease under the Animal Disease and Protection Act so that a regime of depopulation, cleaning and disinfection was followed on each positive premises. Despite this approach, infected hogs have been identified from twenty-nine different premises within the Halifax focus of infection since 1971. Several producers had infected swine on more than one occasion despite following recommended eradication procedures. Limited numbers of rats have been examined from this area. Of twelve rats captured on one premise, ten were infected with trichinosis (Figure 2). Infected rats have been found in two Nova Scotia communities and in one New Brunswick community outside the enzootic area mentioned above indicating the potential for rats to be involved in trichinosis transmission to swine.

What is being done or can be done to prevent infected meat from

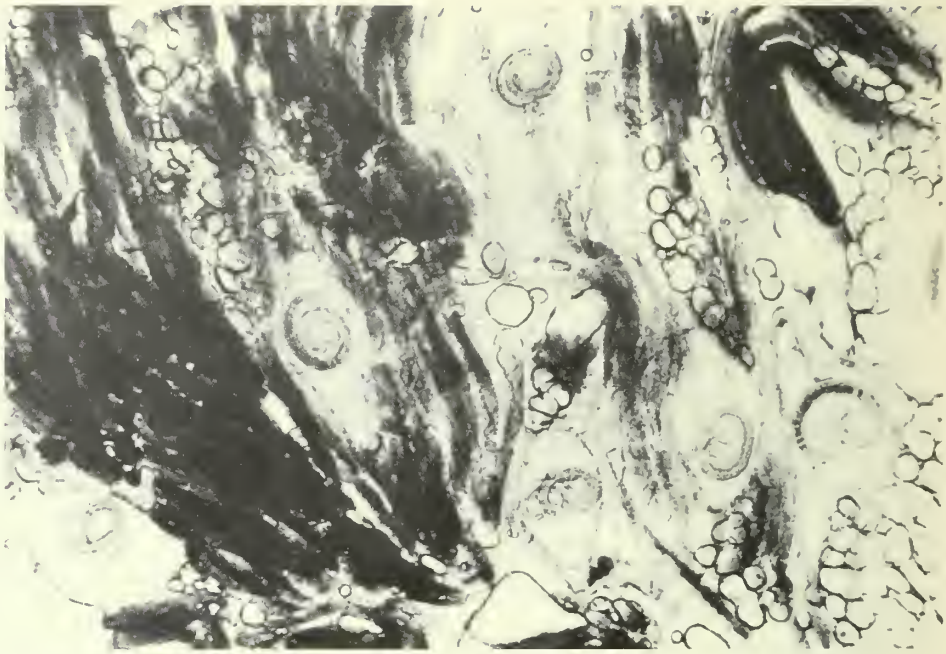


Figure 3 Appearance of Trichinella larvae in musculature as seen with the trichinoscope

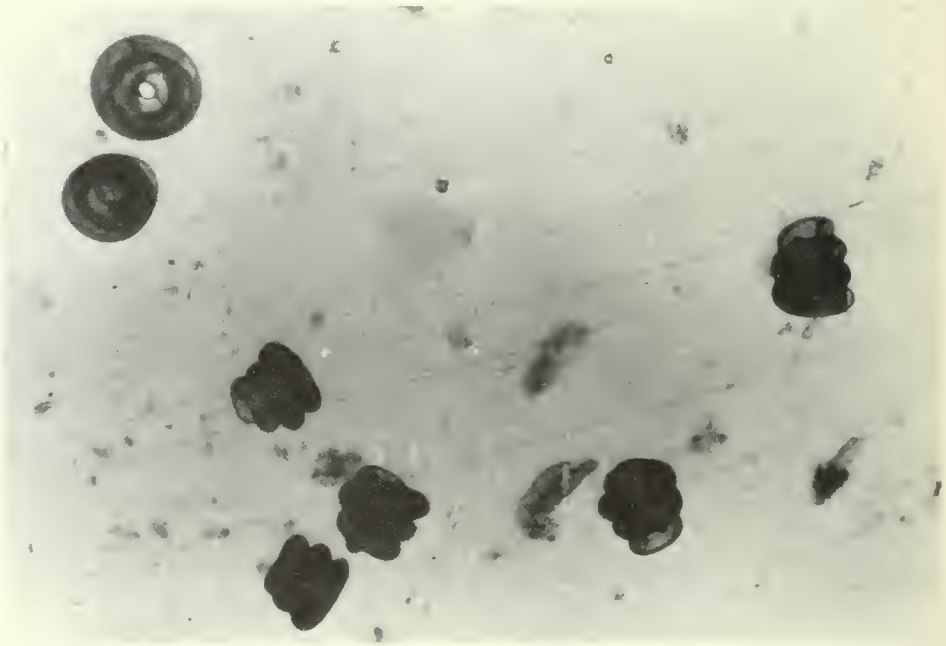


Figure 4 Appearance of Trichinella larvae after release from the musculature by digestion

getting into the human food chain? Meat samples can be examined directly using a trichinoscope (Figure 3) or by pepsin digestion (Figure 4) to demonstrate the presence of Trichinella larvae but these methods have limitations related to amount of tissue that can be examined, the time involved and labor costs. Serologic methods show promise but these have only been used experimentally to date. Despite these limitations, Agriculture Canada veterinarians supervise the examination of hundreds of samples each year. In addition Agriculture Canada regulations regarding the handling of pork and pork products specify treatment by heating, refrigeration or curing (according to prescribed and detailed procedures) of all products except those that are customarily well cooked in the home or elsewhere before being served. Heat treatment to a temperature of 60C will kill Trichinella larvae but the whole thickness of the meat must reach that temperature. Refrigeration work carried out in Canada and the United States showed that a temperature of -15C maintained for 20 days sterilized Trichinella-infected porcine tissue. For lower temperatures the necessary holding period was less. Recently several investigators have reported that an arctic strain of Trichinella remained viable in frozen bear and fox tissues for many months and in one instance for over two years. The difference in survival of the two strains of Trichinella to refrigeration has not been clarified.

Notwithstanding the low incidence of trichinosis in our animals and the efforts by Agriculture Canada to insure that pork and pork products are safe for human consumption, the fact remains that trichinosis is present in rats and in wildlife and the possibility of transmission to man either directly or through infection of meat-producing animals is omnipresent. Owing to the severity and pathogenesis of the disease in man, trichinosis is truly a zoonotic time bomb capable of exploding at any time with sudden and disastrous results. Constant vigilance by officers of Agriculture Canada's Food Production and Inspection Branch is helping to insure that meat and meat products produced in Canada are safe but complete protection from trichinosis ultimately remains with the consumer in the preparation of food.

Dr. Smith is a veterinary parasitologist at Agriculture Canada's Sackville, New Brunswick, Animal Pathology Laboratory

# ERGOT CONTAMINATION OF FEEDS AND FOOD

J.C. YOUNG

L'ergot est un champignon qui parasite diverses graminées et cultures céréalières. Il constitue un important sujet de préoccupation pour tous les secteurs de l'industrie alimentaire.

Lorsqu'une culture est infectée, un ergot se développe à la place des grains sur le plant. A maturité, ces organes tombent au sol ou sont ramassés avec la récolte. Les principaux effets de l'ergot ont été signalés par suite de sa consommation par les animaux domestiques ou du déclenchement d'épidémies chez l'homme.

L'ergot est impossible à combattre par les moyens chimiques. Les bonnes façons culturales s'avèrent encore les meilleurs moyens de lutte.

L'ergot comporte de nombreuses applications médicinales.

Ergot is best known as a disease of rye but this fungus grows parasitically on a wide variety of grasses and cereal crops throughout the world. In Canada, *Claviceps purpurea* has been reported on more than 30 different grasses and the economically important cereals, rye, wheat, barley, and triticale. The fungus produces sclerotia or "ergot bodies" (Figure 1), which

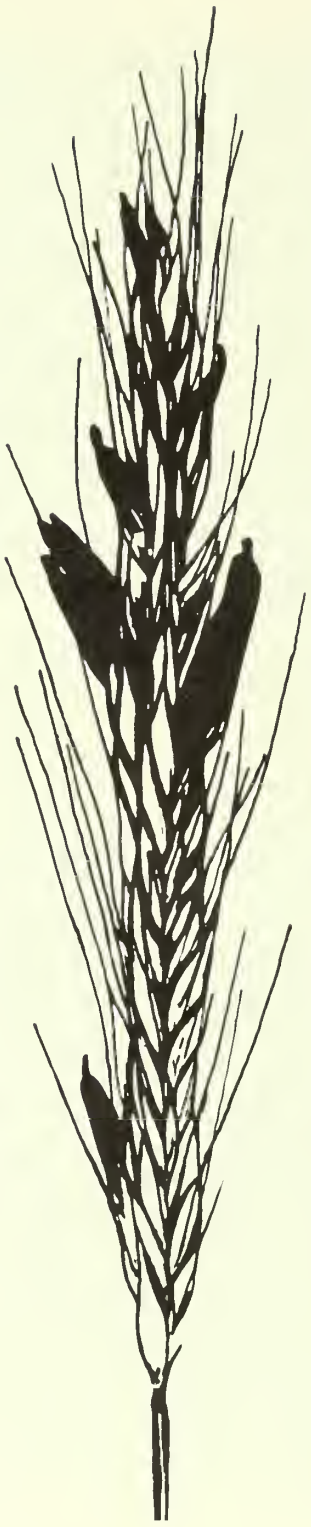
contain a mixture of chemicals including alkaloids that may cause toxic effects when consumed.

Ergot contamination is of concern to all sectors of the food production industry: for the cereal grower it can mean reduced yield and downgrading at the elevator; for the feed manufacturer, unacceptable formulations; for the livestock and poultry producer, reduced performance and quality; and for the consumer, toxins in the food. The farmer who produces feed for his own livestock may be particularly vulnerable.

The ergot life cycle begins in the spring when overwintered sclerotia germinate and the resulting spores are wind-borne to grains and grasses. Infection occurs during the flowering stage. After primary infection, a sticky substance called honeydew is produced and contains spores that can be further spread by insects or rain. An ergot body grows in place of the kernel and at maturity or harvest may fall to the ground or be collected with the crop. Sclerotia tend to be larger than the seeds they replace (Figure 2) and are easily recognized by their dark outer covering and grey-white interior. When ground into feed or flour, chemical or microscopic tests may be required to determine their presence.

The degree of infection is highly variable from year to year and may depend upon factors such as:

- plant species — cross pollinating species (rye and triticale) usually take longer to become fertilized than do self pollinators (wheat and barley) and thus are more susceptible;
- weather — a cool damp spring favors spore production and increases the time for plant fertilization and a hot dry summer promotes sclerotial growth;
- wild grasses — grasses allowed to grow around a field may produce sclerotia and honeydew that can infect a crop, particularly at the edges; and
- farming practices — shallow or no tillage leaves ergot bodies near the soil surface where they are ideally suited for germination whereas deep tillage may cover them with enough soil (about 5 cm) to prevent release of spores. Use of herbicides tends to increase male sterility in cereals, which increases the likelihood of infection. Lack of crop rotation may foster a buildup of ergot in a given field.



The 1978 western Canadian red spring wheat crop suffered higher than normal incidence of ergot with about 1 per cent of the grain cars inspected by the Canadian Grain Commission over a three-month period being downgraded because of ergot.

Unfortunately, ergot cannot be controlled by chemical means and a farmer must rely on proper cultural practices to reduce the incidence of ergot body formation. There are some seed cleaning techniques available to help the farmer after the fact, however they may be costly.

Chemical analyses of Canadian rye ergot have shown that there can be significant variations in the alkaloid content and composition of individual sclerotia. Up to 40 fold differences in total alkaloid content have been observed even from within the same field. There are some regional differences in alkaloid content and composition; levels tend to be lower in Prince Edward Island. Among the dozen or so alkaloids present, ergotamine is the predominant one in the Maritimes whereas in Central

Canada and on the Prairies it is ergocristine. From initial studies, the composition of western Canadian wheat ergot appears to be similar to that of rye ergot from the same region.

Research is underway to determine the toxic levels and effects of individual alkaloids on poultry and it is hoped that similar studies on swine, cattle, and sheep will be initiated in the future. The resulting data will be combined with chemical analyses to estimate the potential toxicity of ergot contaminated feeds. Estimations using published laboratory animal toxicity data and analytical results from Canadian rye ergot have shown that up to a 230 fold difference in potential toxicity may exist between two individual ergot bodies that otherwise appear to be identical. Furthermore, an ergot body from a given field that was calculated to be the one most toxic to a rabbit was the one least toxic to a mouse. It appears likely that the effects of ergot from different sources on livestock and poultry will be highly variable.

Figure 1 Ergot infection in heads (l to r) of triticale, wheat, rye, and timothy

When domestic animals eat ergot contaminated feed, some of the following effects may be observed: behavioral changes such as convulsions, muscle incoordination, lameness, difficult breathing, salivation, and diarrhoea; dry gangrene and loss of extremities such as hooves, tails or ear tips; reproductive effects such as abortion, altered reproduction rate and reduced lactation; feeding effects such as unpalatability, reduced feed intake and weight gain, and increased feed/gain ratio; and death. Young animals are affected more than adults. Recovery from most symptoms, other than advanced gangrene, is usually observed when the animals are given clean feed. Only the feeding effects appear to be common to most animal species; otherwise, a given effect will depend upon the species, ergot source, amount eaten, and period of exposure.

It has been generally recommended that feeds containing greater than 0.1 per cent ergot by weight not be given to animals. Some animals may be able to tolerate higher levels in their feed. Results from current research programs may enable an assessment of the relative safety of particular feed samples.

Humans are also affected by ergot. There have been innumerable epidemics down through the ages with up to 40 000 people affected at a time. Although ergot bodies were first recognized as causing the symptoms of ergotism in 1673, epidemics have been reported as recently as 1951. In

years when there were low crop yields, people were often forced to eat ergot contaminated grain.

When large amounts of ergot are consumed in a short period, convulsive ergotism is observed. The symptoms include itching, numbness, severe muscle cramps and spasms, convulsions, extreme pain and occasionally death. When smaller amounts are consumed over an extended period, the symptoms of gangrenous ergotism are observed. These include cramps, swelling, inflammation, alternating freezing and burning sensations and numbness. Hands and feet may eventually turn black, shrink, and fall off.

The symptoms observed in humans and animals are largely due to two physiological effects; some alkaloids cause contraction of certain muscle fibers whereas others cause constriction of blood vessels, particularly in the extremities. These properties have prompted the therapeutic use of certain ergot alkaloids. Ergometrine (also known as ergonovine) has been used to induce labor and reduce postpartum bleeding; migraine headaches are often treated with ergotamine. Other naturally occurring ergot alkaloids and their derivatives are actively being tested for possible therapeutic applications. These compounds have very complex chemical structures and at present are obtained by purposely infecting fields of rye and later extracting the mature sclerotia or by culturing the fungus.

The majority of reported cases of ergotism in recent years have been due to overdoses of ergot alkaloid drugs. Recovery from acute symptoms can be assisted by proper medication.

Figure 2 Ergot sclerotia (at left in each photo) can be distinguished from the seeds of cereals and grasses by their size, shape, and colour. Upper left—Rye, upper right—Brome, middle left—Barley, lower right—Timothy; lower left—Wheat

There have been only a few reported studies on the presence of ergot alkaloids in the tissues and milk of animals that have consumed ergot contaminated feeds. In no case were alkaloids detected. There is always a possibility that ergot might be found in flour, however close inspection of the grain by the millers should keep this to a minimum. Ergot levels tend to be reduced by the milling process. Thus, the consumer need not be overly concerned about ergot contamination of foods.

For further information, see Agriculture Canada Publication No. 1438, "Ergot of grains and grasses".

Dr. Young is a research scientist with the Environmental Chemistry Section of the Chemistry and Biology Research Institute, Agriculture Canada, Ottawa

# EVALUATING THE BREEDING SOUNDNESS OF BEEF BULLS

G.H. COULTER

Il est essentiel d'avoir un excellent potentiel de reproduction chez le mâle et la femelle pour espérer tirer tout le parti-possible d'un troupeau de bovins. Le choix du taureau est tout particulièrement important à cet effet.

Lors de l'évaluation des aptitudes de reproduction du taureau, on doit tenir compte de trois facteurs en particulier: la grosseur des testicules et du scrotum, tout en tenant compte de la qualité du sperme du sujet, l'aptitude physique à saillir les femelles et la libido (comportement sexuel).

Excellent reproductive performance from both the male and female is essential to optimize profits from a beef herd. The bull is particularly important because he is expected to impregnate many females. Therefore, the bull should be given a proportional amount of consideration when being evaluated for reproductive capacity or breeding soundness.

Three characteristics of a bull should be examined during a breeding soundness evaluation. These are his testicular and scrotal development including seminal quality, his physical ability to breed females, and his libido (sexual behavior). All three aspects must be evaluated before the breeder can be assured that the bull is of at least average fertility.

Although differences exist among breeds in the rate of testicular growth, the testicular size when bulls reach puberty and when they can be expected to be of acceptable fertility are similar for most breeds common to Canada. The main factors with which the breeder must be concerned when evaluating the testicular size of young bulls in his herd are bull age and level of fleshing.

The recommended minimum acceptable testicular sizes, based on measurements of scrotal circumference (SC), for young beef bulls in good condition, such as those completing a 140-day performance test, are 32.0, 33.5, and 35.0 cm for 1-, 1.5-, and 2-year-old bulls. To take an SC measurement, the testes must be palpated gently down into the lower scrotum. A looped measuring tape is then placed up over the testes-scrotum and tightened loosely around the neck of the scrotum. The tape is slid slowly downward, enlarging until the greatest circumference around the testes-scrotum is reached (Figure 1) at which point the looped tape falls off and the scrotal circumference can be read. This procedure should then be repeated to confirm the first result. It is important that the slide on the loop (Figure 1, S) has only enough tension to prevent it from moving by itself. Repeatable measurements are obtainable with this technique but adequate restraint of the bull in the form of a headgate and squeeze is essential for

accuracy as well as to protect the person taking the measurements.

The scrotum of bulls should be of a conformation that will allow the temperature of the testes to be easily regulated. The process of sperm production is highly temperature-sensitive. A normal scrotum is thin, soft, and pliable. When the testes are fully descended, as they would be on a hot day, there should be a distinct neck to the scrotum. Less desirable scrotal shapes include the straight-sided and tucked-up scrotum. The latter tends to come to a point at the bottom. Bulls having these less desirable scrotal shapes tend to have smaller-than-average testes that often produce semen of poor quality.

The quality of semen produced by the testes is of the utmost importance. The two most useful seminal characteristics in evaluating seminal quality under field conditions are progressive motility and morphology of the sperm. Although the astute breeder can easily take an SC measurement and evaluate scrotal conformation, seminal quality evaluations should be conducted by a qualified veterinarian or other professional with specific training in this field. A note of caution should be mentioned. A bull that is found to be unsatisfactory based on one seminal collection and evaluation should not be considered infertile and culled immediately. At least two subsequent seminal evaluations should be conducted at 3- to 4-week intervals. If these ejaculates also prove to be of poor quality, the bull should not be considered for use at the time. In contrast, an ejaculate of high quality is usually indicative of spermatozoa having acceptable fertility. Because a bull may lose his seminal quality quickly and recover slowly, the time interval between seminal evaluation and use as a breeding bull should be minimized.

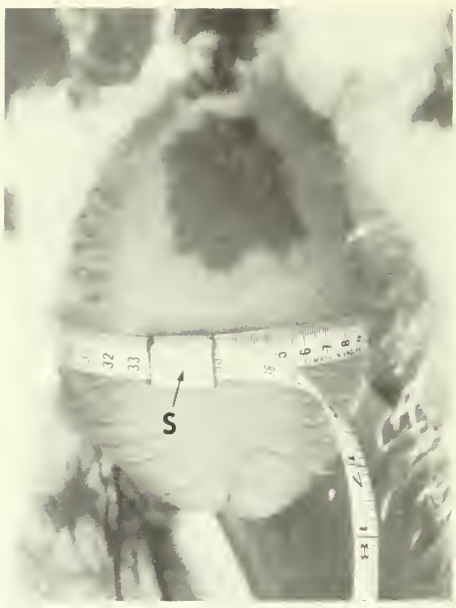



Figure 1 Photograph of a plasticized-cloth tailor's tape formed into a sliding loop for use in measuring the scrotal circumference of bulls. The slider (S) in this tape is made from a small, rectangular piece of cork and reinforced strapping tape. The scrotal circumference of this yearling Hereford bull is 33.5 cm.

Having a normal scrotum and testes of adequate size that produce large numbers of high-quality spermatozoa is of little consequence unless the bull has the ability to seek out, mount, and copulate with estrous females under rough, range conditions. The rather complex act of mounting and copulation provides ample opportunity for problems that can impede reproductive performance. When evaluating a bull for breeding under range conditions one of the primary considerations is the feet and legs of the bull. Efforts must be made to guard against prospective herd sires having either post legs or sickled hocks, as well as to ensure normal foot and hoof development. A second essential component is the bull's ability to have and maintain an erection and be able to protrude his penis normally without deviations that might impair his mating ability. Several pathological conditions and injuries can impair normal penile protrusion. This aspect of the breeding soundness examination can best be conducted by the breeder while watching the breeding activity of his bulls during libido testing. A rectal examination of all potential herd sires should be conducted by a veterinarian to ensure that the accessory sex glands are normal and free from infection.

Without adequate sexual desire by the bull to breed estrous females, it matters little whether the bull is reproductively normal otherwise. Libido is one of the more difficult characteristics to evaluate. The most common method of testing a bull for adequate libido is to expose him to two estrous virgin heifers. If the bull breeds both heifers repeatedly in a short time, the breeder can be assured that the bull has good libido. On the contrary, if no interest is shown in the heifers, the breeder must seriously question the bull's breeding potential. Caution must be exercised when evaluating the libido of virgin yearling bulls so that inexperience is not confused with lack of libido. Again, the evaluation of libido or sexual behavior can best be conducted by the conscientious breeder.

Most traits associated with poor reproductive performance, which include underdeveloped testes, poor seminal quality, abnormal-

ities that prevent penile protrusion, low libido, etc., are moderately to highly heritable. Therefore, bulls having these conditions must be considered for culling.

The three components of a reproductive capacity or breeding soundness evaluation as outlined should be considered as qualitative rather than quantitative. If these recommendations are followed, average to above-average fertility would be expected from bulls passing these tests; however, to attempt an accurate ranking of bulls as to their fertility using these tests would probably not be productive.

All aspects of reproductive capacity or breeding soundness must be examined for all potential herd sires if herd reproductive performance is to be maximized.

Dr Coulter is a Reproductive Physiologist at the Agriculture Canada Research Station, Lethbridge, Alberta

# ECHOES
## FROM THE FIELD AND LAB

**WEATHER DAMAGE IN MATURE WHEAT CROPS** Weather damage after maturity is a major factor affecting grades of hard red spring wheat in western Canada Agriculture Canada's Swift Current, Sask., Research Station is breeding varieties resistant to this type of damage.

Researchers are studying several different lines of wheat exposed to the elements this fall.

Information gained from these studies should provide guidelines for wheat breeders by early 1980.

**Les Floralies Internationales de Montreal** Approved by the International Association of Horticultural Producers and the International Bureau of Exhibitions, the Floralies internationales de Montreal is being held May 17 to September 1, 1980 The site of the XXI Olympiad of 1976 will serve as the theatre for first meeting in America of the world's major horticultural traditions

The Floralies Internationales is being sponsored jointly by the city of Montreal and the Quebec Ministry of Agriculture under the ageagis of the Canadian Secretary of State for External Affairs The purpose of the floral exhibition is to foster the development of all forms of ornamental horticulture and to demonstrate the progress achieved by horticulture at the international level Other objectives include stimulating research in the areas of cultivation and horticultural teaching, and to serve to inform the public about the ecology and its problems and about the importance for all people of living in a healthy environment

**DEVELOPING PEANUT POTENTIAL** Researchers in southern Ontario are in the home stretch of their six-year effort to help establish a viable peanut industry Commercial production and processing should be underway within one to two years

Agriculture Canada's New Crop Development Fund has helped in the search for the ideal varieties and cultural techniques This year the fund will contribute $24,000, bringing total contributions to $539,000 since 1974

Tests conducted by a University of Guelph team, have shown that the area can yield more than 2 2 tonnes per hectare, thus making peanuts a potentially profitable crop for farmers

**SOIL TESTING MAKES SENSE** Soil testing can tell a farmer when to add fertilizer to his land It can also tell him when to leave well enough alone

"In parts of Canada where fertilizers have been used for many years, levels of phosphorus, potassium and nitrogen can be quite high," says Wally Findlay, head of the horticultural and soil science section at Agriculture Canada's Harrow, Ont., Research Station

"Farmers in these areas who continue to add fertilizer may be wasting money as well as damaging the environment"

Dr Findlay has been studying fertilizer recommendations based on soil tests

"I wanted to arrive at 'economic threshold' levels of fertilizers for major crops grown in southwestern Ontario After these levels are reached, it's not economical to add more," the scientist says

Phosphorus, because it is not used rapidly by crops, builds up in the soil. Excess amounts can be washed into water systems and cause pollution problems.

Too much nitrogen is not normally a problem, but in some areas heavy use of nitrogen has left an acidic residue in the soil. This can lead to stunting, yellowing or poor root development in the crop, particularly on sandy soils.

Dr Findlay's research has reaffirmed that many recommended fertilizer levels are accurate and that soil testing is the best way to determine the needs of the soil

He suggests that farmers who had problems with their crops last year, and who have not yet sampled their soil could take samples in early spring and have them analyzed

"It's better if only those farmers who had problems last year send in samples this spring The soil-testing laboratories are usually very busy at this time of year," he says.

For longer-term soil management, Dr Findlay recommends testing in the fall.

"This leaves plenty of time to have samples analyzed and get recommendations before ordering fertilizer needs for the spring"

The scientist says it is best for Ontario farmers to have their soil samples analyzed at a laboratory in Ontario rather than at one outside the province

"A sample analyzed in southwestern Ontario, for instance, will take into account local growing conditions and these will affect recommendations," Dr Findlay says

# ECHOS
## DES LABOS ET D'AILLEURS